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16. Abstract (MAXIMUM 200 WORDS)  The present study addressed the applicability of investigation, reporting, and analysis procedures that focus on the role of mariner skill and knowledge limitations in marine casualties. An initial set of procedures was used during a trial implementation by Coast Guard Investigating Officers in their investigation of 389 marine casualties. The procedures were found to be effective. Analysis of the resulting casualty reports provided a basis for determining the prevalence and characteristics of skill and knowledge limitations in marine casualties, as well as the identification of investigator recommendations corresponding to specific causes. Skill and knowledge limitations were found to contribute to 22% of critical casualties, with errors in bridge operations being the predominant cause. The investigation tools allowed for the identification of the specific operational activities which were performed incorrectly and led to the casualty. This information provides the maritime community with specific areas in which improvements are needed in mariner education and shipboard operating procedures. Following the assessment of the initial procedures and analysis of the casualty data, a set of revised investigation tools was developed.					
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## EXECUTIVE SUMMARY

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It is estimated that human error directly contributes to between 75 and 96 percent of marine casualties (U.S. Coast Guard, 1995A). Gaining a better understanding of the nature and causes of casualties with human factors contributions will help in identifying strategies to reduce future marine casualty rates. The U.S. Coast Guard (USCG) routinely investigates marine accidents for cause, providing the potential for significantly reducing marine casualty rates. Two recent USCG Research and Development Center studies demonstrated the value of conducting marine casualty investigations that focus on individual human factors causal areas. These studies, which focused on mariner fatigue (McCallum, Raby, & Rothblum, 1996) and communications problems (McCallum, Raby, Forsythe, Slavich, Rothblum, & Smith, 2000), involved the investigation of a limited sample of marine casualties, yielding an initial characterization of the nature of human factors contributions to casualties in these two areas. In addition, the studies provided investigation tools for application by USCG Investigating Officers (IOs).

The present study focused on the role of skill and knowledge limitations in marine casualties, using the basic approach of the two earlier studies. This study had two objectives:

- Develop a method and tools that can be applied to investigate and report casualties involving skill and knowledge limitations.
- Provide an initial characterization of mariner skill and knowledge limitations that contribute to marine casualties.

We developed an initial set of procedures used to investigate and report on the contribution of skill and knowledge limitations to marine casualties. The procedures were then applied by IOs from four USCG Marine Safety Offices (MSOs) to collect a sample of casualty reports and identify issues. Our analysis of a sample of 389 casualties provided a number of insights into the specific skill and knowledge limitations that most commonly contribute to critical marine casualties. Finally, the investigation and reporting procedures used in the present study were reviewed and a set of revised procedures were produced, suitable for application by USCG IOs to investigate the contributions of skill and knowledge limitations to marine casualties.

Extensive time and effort were invested in the initial development of the procedures used in this study. During development of the procedures, a comprehensive list of activities associated with bridge, deck, engineering, and safety and emergency operations was defined and incorporated into the procedures. The definition and classification of operational activities represents the combined efforts of human factors and maritime experts. These efforts focused on developing easy-to-use forms that would maintain sufficient detail to address specific skill and knowledge limitations.

Our experience applying these procedures has demonstrated that significant time must be allocated for in-depth investigation of human factors causes. One of the current objectives of the USCG Office of Investigations and Analysis (G-MOA) is to expand the breadth and depth of human factors data available for analysis of cause. The systematic investigation of human factors causal information requires personal contact with the individuals directly involved in the casualty and the application of detailed standardized

procedures, requiring substantial investigator time. This conclusion is consistent with the two earlier studies in this series (McCallum et al., 1996; McCallum et al., 2000).

The Office of Investigations and Analysis has made significant progress recently in improving the quality of investigations into human factors causal areas. Recent additions to investigator training have increased the general level of awareness concerning human factors among the IOs. Additionally, G-MOA's guidance to focus on critical casualties has allowed IOs to spend more time on casualties representing significant risks to property and personnel safety. However, further development and implementation is required to establish a comprehensive process for the investigation and reporting of human factors causes. A systematic set of investigation tools that is integrated with standardized reporting procedures is required to successfully implement this approach. In addition, because of the extensive time required to investigate human factors causes, guidance must be provided regarding when it is appropriate to conduct such in-depth investigations.

Although the present study was limited to a sample of 389 casualties, it helped to characterize and quantify the extent to which mariner skill and knowledge limitations contribute to marine casualties. The incidence of skill and knowledge limitation contributions to critical casualties was determined to be approximately 22 percent, indicating that this area is a significant contributor to marine casualties and is worthy of government and industry attention and remedial action. The current procedures provided data that were useful in identifying the mariner activities associated with skill and knowledge limitations that contributed to the sample casualties. However, further investigation will be necessary to identify the specific skill and knowledge areas requiring remedial action.

The research procedures required IOs to investigate all casualties resulting from unsafe acts by mariners. Following the trial implementation of these procedures, a tool was developed that researchers used to classify unsafe mariner acts. This tool was further refined so that it could be used to reliably classify unsafe acts into the five categories of violations, rule-based mistakes, knowledge-based mistakes, slips, and lapses. This tool could be used by IOs to analyze casualties and identify those cases that were a result of mariner skill and knowledge limitations (i.e., those resulting from rule-based and knowledge-based mistakes).

The in-depth procedures used to investigate skill and knowledge limitations in the present study were based on subsets of a detailed list of operational activities. These procedures were found to be useful in characterizing mariner skill and knowledge limitations, as well as in providing IOs with a focus for developing recommendations for reducing future casualties. Streamlined investigation forms based on these procedures have been prepared to provide a common structure for the future in-depth investigation and reporting of skill and knowledge limitation contributions to casualties. It is recommended that these tools be implemented to obtain additional information regarding specific skill and knowledge limitations, potential underlying contributing factors, and remedial actions.